CONSULTANT REPORT

LIGHTING EFFICIENCY TECHNOLOGY REPORT

Volume III MARKET BARRIERS REPORT

SEPTEMBER 1999

CALIFORNIA ENERGY COMMISSION

Gray Davis, ***Governor***

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C A L I F O R N I A E N E R G Y C O M M I S S I O N

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This report is one of several being prepared under the *Lighting Technology Assessment Study* for the California Energy Commission. The study is being done as part of the Commission's response to the 1993 California Senate Bill SB 639 in which the legislature requested recommendations on ways to improve the efficiency of lighting in California.

The Commission's project manager for this study was initially Fred Berryman, and then John Sugar, with support from David Jones, and Ross Deter. The contractor team was led by the Heschong Mahone Group, Lisa Heschong and Douglas Mahone, Partners. Data analysis was provided by Ken Parris of B.E.A.R. The California Lighting Model was developed and run by Eley Associates, Charles Eley, Principal and Jeffery Luan, programmer. Additional lighting expertise was provided by James Benya and Ken Lim, and market research by Lisa Heschong of Heschong Mahone Group, Doug Oppedal of Benya Lighting Design and Merry Stubbins of SDV/ACCI.

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There are four volumes to this Lighting Efficiency Technology Report:

Volume I: California Baseline Report

Volume II: Scenarios Report

Volume III: Market Barriers Report

Volume IV: Recommendations Report

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1. INTRODUCTION

This portion of the Lighting Efficiency Technology Report focuses on describing market conditions and barriers to implementing lighting efficiency policy options in the state of California. This is a relatively small portion of a year long study assessing the current status of lighting energy use in the state and the most effective strategies for achieving long term energy savings.

This report is one of several being prepared under the *Lighting Technology Assessment Study* for the California Energy Commission. The study is being done as part of the Commission's response to the 1993 California Senate Bill SB 639 in which the legislature requested recommendations on ways to improve the efficiency of lighting in California.

Members of the project team, in discussion with members of LEAGue, developed a number of lighting scenarios which could result in significant energy savings in California. These scenarios were studied using the California Lighting Model, and the results are reported in the Scenarios Report, as part of this project.

A search of current literature was conducted on market barriers to efficient lighting in both residential and commercial applications. From this search, we identified areas that needed additional clarification. To avoid duplication we focused on areas that were not currently under study elsewhere, and that would likely be most useful in helping to illuminate the scenarios being considered in the report. Consumer acceptance of CFL lamps had been studied the most extensively, by a number of utilities and EPRI. Market structure of portable residential lamps, along with the domestic vs. import markets, was studied carefully by EPA. One California utility was currently sponsoring market research on CFL bathroom vanity lights. LBNL was currently investigating the market size and structure of HID lighting.

1.1 Objectives

We identified five basic areas of inquiry. These included barriers to greater market penetration of five basic efficient lighting approaches:

1. Fluorescent residential fixtures (indoors and outdoors)
2. Compact fluorescent commercial fixtures
3. Residential lighting controls (indoors and outdoors)
4. Skylights and photo controls in commercial buildings
5. Education and certification of lighting professionals

For each of these approaches to efficient lighting, we wanted to identify the most salient market barriers that might exist for market actors at any level. These included:

- **Manufacturing barriers, such as:**
  - cost of changing manufacturing equipment, limitations on supply of materials
  - technical difficulties in producing product
  - poor information flow from OEMs to “assemblers”
  - warrantee problems, reliability worries
- **Distribution barriers, such as:**
  - handling problems: product too fragile, too big, too small, SKU IDs,
  - market area too diffuse, too small
  - poor information flow from manufacturers to distributors
  - distribution system unreliable or disorganized
  - distribution system slow to accept new products
- **Marketing barriers, such as:**
  - product introduction costs, difficulty in differentiating from competing products, difficulty in communicating value of product,
  - difficult to target market: market too specialized, or limited
  - fluctuating market conditions (construction boom and bust…)
- **Institutional barriers, such as:**
  - conflicts with codes, such as fire, energy, structural/seismic or NEC
  - difficulties with UL rating or insurance requirements
  - need for other special ratings or approvals
- **Equipment barriers, such as:**
  - lack of compatibility with other equipment in buildings (RF interference, surges…)
  - lack of coordination with other manufacturers (lamps incompatible with ballasts…)
  - lack of support from associated products (no fixtures designed for CFL lamps…)
  - Coordination with too many other products (skylights, flashing, controls, sensors, etc., all sold by separate companies)
- **Practice and/or installation barriers, such as:**
  - lack of knowledgeable architects, engineers, contractors
  - cross-discipline confusion, too much coordination by variety of disciplines
  - requires specialized labor to install
  - need for excessive calibration, adjustments
- **Consumer barriers, such as:**
  - difficulty comparing products, poor information flow to consumers
  - unacceptable performance (hum, bad CRI, no dimming, slow startup…)
  - poor aesthetics (no sparkle, poor light distribution, excessive brightness…)

- facility management issues (too many parts, ordering, maintenance issues…)

We were more interested in an exploratory approach to identify and describe any market barrier, than a rigorous effort to prove or disprove a hypothesis or to quantify the impacts of a given barrier. Thus, we chose to use open ended interviews as much as possible with the widest possible array of market actors, given the limited budget. We choose to focus on the five following groups:

- ***Manufacturers***
  - *Residential indoor fixtures*
  - *Residential outdoor fixtures*
  - *Commercial CFL fixtures*
  - *Residential and Commercial controls*
  - *Commercial Skylights*
- ***Commercial lighting professionals***
  - *Lighting Designers*
  - *Electrical Engineers*
  - *Electrical Contractors*
  - *Electrical Design/Build Contractors*
  - *Lighting Maintenance Companies*
- ***Residential lighting contractors***
  - *Electrical Contractors*
  - *General Contractors*
- ***Residential lighting retailers***
  - *Lighting showrooms*
  - *Lighting specialty stores*
  - *Hardware stores*
  - *Big box retailers*
- ***Utility efficiency program representatives***
  - *PG&E*
  - *SCE*
  - *SDG&E*
  - *SMUD*

1.2 Methodology:

Over 150 telephone interviews were conducted, lasting from ten minutes to a hour. A diverse, representative population was identified for each group. For those groups with a very limited population, such as manufacturers or utility efficiency representatives, we conducted in-depth telephone interviews with a targeted list of participants. For those groups with a larger population, such as lighting retailers, we conducted structured phone surveys with a stratified random sample.

The following surveys were conducted to assess the status of market barriers to various lighting efficiency measures.

1.) Lighting Fixture and Controls Manufacturers
- Targeted Interviews

2.) Commercial Lighting Design and Engineering Professionals
-Stratified Random Sample

3.) Residential Lighting Contractors and Builders
-Stratified Random Sample

4.) Residential Retailers
-Stratified Random Sample

5.) Utility Energy Efficiency Program Representatives
- Targeted Interviews

6.) Skylight Manufacturers, Sales and Design Professionals
- Targeted Interviews

The manufacturers and professionals selected for the targeted phone interviews were chosen based on our team's knowledge of the important players in the given field. As many interviews from this predetermined list were completed as possible within the allotted time period and budget. The interviews followed a list of prepared questions, but took the form of a relaxed collegial discussion.

The interviewees for the stratified random samples were picked randomly from phone books based on a predetermined quota of designated business types and geographical locations. Of the over 90 telephone surveys that were conducted, ½ addressed market barriers in the residential sector and ½ in the commercial sector, and ½ were targeted at Northern California and ½ at Southern California. In addition we made sure that 10-15% were from areas outside of the major metropolitan regions of California.

For these telephone surveys we used a formal survey instrument, with qualifying questions, and with a combination of quantitative and open ended responses.

Where ever possible we asked for an approximate number that would be easy for the respondent to judge quickly, such as “how many different products of this type to do have on your shelves?” We also used hypothetical scenarios and asked for ratings of a likely action on a scale of 1-5. These scenario responses are particularly revealing of the respondents attitudes. For questions asking for frequency, interviewees were allowed to make their own judgment about the meanings of “usually,” “frequently,” “occasionally,” “rarely,” or “never”. If they asked for guidance, they were given specific ranges: “usually =76-100%,” “frequently=26-75%” “occasionally=6-25%” “rarely=1-5%” or “never=0%”. After each quantitative question, the interviewee was also asked for any open ended comments or reasons for their response.

Interview forms and summary sheets are attached in the Appendix to this report.

2. MANUFACTURERS' MARKET PERSPECTIVE

A group of 40 manufacturers, primarily of residential lighting fixtures, but also including commercial fixtures and lighting controls, were identified for interviews. Twenty-three of these were ultimately interviewed over the telephone. The interviews were conducted primarily with the company president or vice president. Or in a few cases when they were unavailable or for the larger companies, the interview was conducted with the national or regional marketing manager or product manager.

For manufacturers the research objectives were to determine

1.) the manufacturers' view of the major market influences on lighting efficiency for their products;

2.) if the California market had noticeably different characteristics than other regions of the country, and if so how and why; and

3.) describing any particular problems or "barriers" that they experienced in trying to achieve a larger market for their most efficient products.

Lighting fixture manufactures typically design their products for a specific lamp configuration, but do not include a lamp with the product or specify a lamp manufacturer. For those lamps which are driven by a separate ballast, such as full size fluorescents (FFLs), pin based compact fluorescents (CFLs), or HIDs, the ballast is typically included with the fixture. Thus, the manufactures will select a particular manufacturer to provide ballasts to be incorporated into their fixtures. This choice of ballast will also determine which lamp types can be used in the fixture, and sometimes, which specific manufacturer of lamps can be used.

The lighting manufacturing industry has something of a pyramidal structure, with three main lamp manufacturers at the top, with a few dozen ballast manufacturers in the middle, and hundreds of fixture manufacturers at the bottom. Innovations with new lighting products usually start with the large, international lamp manufacturers, who have large research and development budgets. The ballast manufactures then respond to the new ballasts designed to drive the new lamp products, and the fixture manufactures are last to respond. They are a key link in bringing out new fixtures specifically designed to utilize the new lamps, and which incorporate the appropriate ballasts to drive the lamp.

The fixture manufactures then market their products in a very competitive environment, against dozens of competing fixture manufactures, both domestic and foreign. Commercial fixtures are most commonly marketed to intermediaries, such as lighting design professionals and installers, while residential fixtures are marketed directly to the consumer.

The summary of manufacturers interviewed and their product lines is shown below in Figure 2-1.

			Residential										Commercial										Both			
Mfg	Manufacturer Name	State	**Outdoor Fixtures**	w/ CFL	w/ HID	w/ controls	**Indoor Fixtures**	high end	decorative	utility	w/ CFL	w/ other ee lamp	**Outdoor Fixtures**	w/ CFL	w/ HID	w/ controls	**Indoor Fixtures**	high end	decorative	utility	w/ CFL	w/ other ee lamp	**Controls**	Occupancy sensor	Dimming controls	Photosensor
1	Enertron Technologies	CA	③				③										③									
2	Trimble House	GA	③				③						③				③									
3	Light Way Industries	CA	③										③				③									
4	W.F. Harris Lighting	NC	③																							
5	Unenco	CA																					③			
6	Sensor Switch	CA																					③			
7	Bega	CA	③				③						③				③									
8	Neoz	Can.					③										③									
9	Brass Light Gallary	WI	③				③										③									
10	Lutron Electronics Co	PA																					③			
11	Wila	FL					③										③									
12	Lumatech	CA					③										③									
13	Thomas Industries	CA	③				③						③				③									
14	Teron	OH	③				③						③													
15	Scientific Components	CA															③									
16	Prescolite	CA					③										③									
17	CSL Lighting	CA					③						③				③									
18	Lumiere	CA	③				③						③													
19	Brownlee	FL	③				③						③				③									
20	Shaper	CA	③				③						③				③									
21	Edison Price	NY					③										③									
22	Seagull	NJ	③				③										③									
23	Lightolier	OR	③				③						③				③						③			

Figure 2-1 - Manufacturers Interviewed

2.1 California As An Influential Market

All of the manufactures surveyed see California as an important or essential market for their product. Most manufacturers reported that they sold 10% to 20% of their overall product in California. They universally see significantly higher sales of their energy efficient products to California. One manufacturer said "10% of our product goes to California, and 40% of our CFL products." An international company reported: "5-10% of all our products are sold there. 95% of those are CFL." An outdoor fixture manufacture said : "Most everything that goes to California is either CFL or HID."

Many mentioned that they perceived the players in the California market to be more sophisticated and educated, and important in setting trends for the rest of the country, not only in energy efficiency requests, but also in terms of style or custom applications.

- "Californians are the drivers for new trends." "There are more trend setters in California." "We are seeing new trends from California, such as custom CFL fixture requests from lighting designers."
- "California has greater market maturity, acceptance of CFL products."
- "The inventory in California is more energy efficient than most areas."
- A controls manufacturer commented: "California has better educated consumers and retailers. For example, there are 50 people signed up for our class in California and none in the northwest."
- A number of manufacturers commented on specifically designing their products to meet the demand from California: "We have adapted our product to the increased requests for CFL and HID from California."

Other areas of the country were described as following California's lead.

- "We see Washington and Oregon following California energy efficiency lead."
- "The people in the Midwest don't care about energy efficiency. California is the primary market leader, and New England the next most important."

2.2 Title 24 Impacts

California's energy code was acknowledged to be one of the most important influences in the national fixture and control marketplace.

- "California is an extremely important market for us. The CEC has driven us to more unique designs for the residential market. Our CFL fixtures are sold 35% in California and increasing. We feel the need to meet the kitchen and bath T24 requirements….This forced the reps to sell higher quality products in California."
- "The biggest single impact on the market has been Title 24. Title 24 accelerated the development of the electronic ballast."
- "Yes, we are seeing more requests for CFL dimming in residences in California. Residential Title 24 in kitchen and bathrooms has spurred the demand for residential dimming. The IESNA RP-1 standard has also increased the demand for dimming [in commercial applications]."
- "Title 24 forced the lighting industry to be more creative…"

- "Title 24 initiated the demand for CFL, but now it is becoming more accepted in general design practice."

- "Changes in Title 24 would not greatly effect our market because most projects in California have sensors now anyway. A nationwide requirement would dramatically increase our sales, because there are may states in the Midwest and South that have never heard of an occupancy sensor."

- "Title 24 has had a big effect on our sales. We see the biggest demand in California, followed by the East. There is very low demand in the Midwest, with the exception of Chicago."

- "We design our fixtures to meet Title 24 first, then we modify them to meet the market towards other parts of the country. We design our fixtures for CFL first, then modify them to accept incandescent. California is a big market for us, but the majority of the U.S. wants incandescent. Our product sales will increase as the rest of the country follows CA's lead in energy efficiency."

2.3 Utility Program Impacts

The impact of utility programs was mixed. Some manufactures credited the utility rebate programs with starting the market trends. Others complained that the programs had had poor specifications, and had confused the market with poor performing products, or inflexible rules.

- "Utility Rebates initially drove the demand for our sensors. Now the rebates are decreasing but the industry is more educated, so we are still seeing the demand in the market."

- "Rebates and T24 started use of controls, but rebates are dissipating now. Control technology is going more mainstream….Most designers and engineers are including occupancy sensors on their projects now without the rebate incentive. There are more people in California who are knowledgeable about sensors."

- "Utility programs have offered rebates on certain ballasts only. That limits the fixture choice, because that manufacturer might not make a ballast for the lamp the designer wants."

- "The utility rebates created an artificial market. Poor performing companies had bad history of product failures, and turned off customers."

2.4 Lamp and Ballast Standardization

The fixture manufacturers were most passionate on one issue: that ballast failures and lamp-ballast incompatibility problems create a major liability and cost

for fixture manufacturers. The fixture manufacturers are on the front lines and get the calls about poor performance of lamp/ballast systems in their fixtures. The cost of any failures are high, in terms of time that has to be spent investigating the problem, correcting the problem, and the remaining ill will created with the customer. The fixture manufacturers are the ones called to go investigate the failures, but it's not a problem they actually created or can fix directly. Rather, they have to go back to the lamp and/or ballast manufacturers for a solution. The risk of failure causes fixture manufacturers to be risk adverse, slowing the use of innovative technologies.

- "We have had problems with lamp and ballast compatibility….If there is a problem in the field, everyone suffers, not just the supplier. From the original specified, to the distributor, electrical contractor, general contractor, and the end user."

- "One of our biggest problems is that new lamps do not have consistent characteristics. The lamp manufactures have lamps that work with only certain ballasts. We have a case in LA right now where our CFL fixture was specified and installed. The lamps started to fail, so we had the lamp manufacturer, one of the "big three", come out to investigate. First they said the lamps were defective, so they replaced all the lamps, and the lamps failed again. Then they said the ballasts were defective. The ballasts were sent out to the other "big three" lamp manufacturers to use in their equivalent lamps. Those lamps and ballasts worked fine. This is what I'm talking about—ballast and lamp characteristics must be compatible. The fixture manufacturer suffers with incidents like this."

- "Voltage variation causes problems for the ballasts. This is an extra cost for us, because we get the call and have to go investigate the problem, but it's really not our problem."

Issuing new lamp technologies also fall as a major cost on manufactures, because they must redesign their fixtures, retool their machinery, and reprint all advertising materials. Thus adopting a new improved technology often has prohibitive start up costs, and the risk of even more cost if the technology changes again in the near future.

The fixture manufacturers are comparatively small, and their cost for field problems is high. The lamp manufacturers are very large, but they spend less time in the field. If these costs could be reduced, or allocated more proportionately, a greater variety of innovative fixtures could be brought to the market quickly and efficiently.

2.5 Redesigning For New Lamps

Compact fluorescent lamp configurations have been changing rapidly in the past decade. Lamp manufacturers have been issuing radically new CFL products every year. The pace of innovation has been dizzying. However, this hectic period of innovation causes major problems for fixture manufacturers, as last year's product line becomes obsolete, and they must invest significant resources in redesigning and retooling for new lamp configurations.

- "It's very important to have the reflector designed to the CFL configuration. You can't just use the same reflector as you would with the incandescent fixtures because of bulb imaging problems. All this causes the cost of the fixtures to increase."

- "Every time the lamp manufacturer changes or introduces a new lamp, we have to redesign the reflector according to new photometrics. We've had problems getting lamp manufacturers to provide us with enough specific information about their new lamps."

Fixture manufactures would benefit from more information from lamp and ballast manufactures. New products are often announced and rushed to market before detailed test results are available on performance. This puts the fixture manufactures who adopt a new technology in the front lines for risk of failures.

The sheer variety of lamp products can also cause significant problems for consumers, who must assess how long it will take to shop for a replacement, or even if a replacement lamp will be available in the future. Consumers are faced with the task of having to carry the light bulb around with them while they shop for a replacement, so that they can be sure the dimensions and base configuration match.

In contrast, screw-in incandescent lamps, the familiar "A-lamp" or "Edison base" have remained constant for decades, indeed most of this century. As a result, replacing the light bulbs for a house built in the thirties is easy, but for a house built today, there might be 5, or even ten, different bulb shapes, some of which are likely to be discontinued in the future.

2.6 CFL Electronic Ballasts

Most manufacturers commented on a trend for increased demand for electronic ballasts. It was acknowledged that for full sized fluorescents, T8 lamps with electronic ballasts have become the standard in California. Electronic ballasts with compact fluorescent lamps, however, were more controversial. Advantages are multiple, including higher light output, better energy efficiency, less heat, less weight, smaller size for easier compliance with ADA requirements, and dimming

capabilities. The major disadvantages are higher cost, high failure rate, and incompatibility with lamps from various manufacturers. Most commented on either past or current bad experience with the ballasts:

- "Electronic ballasts are still a problem, but they are getting better. We see a trend towards electronic ballasts…"
- "Electronic ballasts were initially a problem, but failure are minimal now."

A number of manufacturers had had very bad experiences with electronic ballasts in their products.

- "As of March, we will be discontinuing electronic ballasts in our fixtures. There have been too many failures. The ballast manufacturers are not living up to their end of the bargain. Several electronic ballast companies have closed, which has created a nightmare for us."
- "We sell more magnetic ballasts, because they create fewer problems, although we are seeing demand for electronic increasing because it delivers a higher lumen package."

2.7 Residential Market Drivers

Multifamily housing is perceived to be a big driver in energy efficiency for residential fixtures, especially outdoor lighting.

- "The owners of facilities pay the common area energy and maintenance bills and want to purchase energy efficient products with long lives."
- Senior citizens are a secondary driver for efficient residential fixtures, "since living on a fixed budget, they are sensitive to long term costs."

There is a trend towards better quality residential CFL and FFL residential fixtures, but the majority are still low end utility fixtures for kitchens and bathrooms. High end fixtures usually get a foothold in commercial applications, then custom homes. Improvements in lamp color, instant on, and dimming characteristics, etc. will increase acceptance. Reductions in price will increase residential popularity for both CFLs and controls:

- "If the price of components went down, occupancy sensors would find their way into the residential market. Right now they are only in high end homes."

Higher light output is important to both fixture manufacturers and retailers (low light output from CFL was the most commonly voiced complaint in both the retailers and residential contractors surveys, see sections 3.3 and 4.)

- "We are expecting the lamp manufacturers to shrink the lamps so we can install higher output lamps in our fixtures.

2.8 Overseas Competition

Many manufacturers expressed concern about overseas competition. They commonly spoke of overseas manufacturers copying their products, and selling them at much lower quality, and lower price.

- "It is also hard to compete with overseas companies. We have a good quality product with quality components, but the import market is just a commodity competing on lowest price…Opening the door to the import market makes it difficult to compete and still provide a quality product. …Our product gets copied…We have to go to court for patent infringement, but we can only go so far before it becomes too expensive to continue…"

- "The biggest change in the market has been the moving of suppliers overseas."

- "If OEM product pricing came down dramatically, we would be able to compete with the overseas commodity market pricing. Then we could compete on quality [of fixtures]."

2.9 Other Influences On the Lighting Market

Other than Title 24 and utility programs, only two other important market influences on energy efficiency were mentioned:

- "Green Lights has been a major component that spurred energy efficient fixtures." [only one mention]

- ADA influences the creation of smaller [wall mounted] fixtures that can best be achieved with electronic ballasts. [two mentions]

2.10 Conclusions for Manufacturers

The importance of the California market as the demand leader for energy efficient lighting was stressed by nearly all of the manufacturers interviewed. Most of them specifically cited Title 24 lighting efficiency requirements as driving the market toward compact fluorescents and other forms of efficient lighting. Most are responding to the market created by Title 24 with specific new products. Utility rebate programs were also given some credit in driving a market for efficient lighting, but they were viewed as transitory, and fading as an influence on the market.

The costs of using new energy efficient technologies was a primary topic among the manufacturers interviewed. There are two important aspects to the cost of new technologies to manufacturers. The first is the risk, and reality, of component failure. The second is retooling cost every time lamp sizes and

shapes are changed (by contrast, incandescent form factors have been constant for many years). Thus, improving compatibility between lamp and ballast components, and information flow from the OEMs to the fixture manufactures were the two most important market barriers faced by the CFL fixture manufacturers interviewed.

Residential lighting efficiency trends are lead by senior citizens and multifamily buildings, both of which are looking for long lamp life and economical operation. Additional factors of concern to the manufacturers is cutthroat price competition from abroad.

3. RESIDENTIAL CONTRACTORS' MARKET PERSPECTIVE

In order to learn about lighting efficiency from the residential contractor's perspective, 26 contractors were interviewed by phone. Two thirds of them were electrical contractors, and 1/3 were general building contractors. As a group, their work was evenly split between remodels and new homes. Likewise, about half of their work was directly for homeowners and half for larger developments of speculative homes. The interviewed firms installed lighting in an average of 300 homes per year, for a total of 7,800 homes represented by the sample. The homes were evenly distributed from low-end through luxury homes. Of the contractors, 2/3 were from Northern California, and 1/3 were from Southern California, 4/5 were from the largest California urban areas and 1/5 from smaller cities.

3.1 Installation Decisions and Fluorescent Fixtures

Installing fluorescent fixtures seems to be a common occurrence for this group. All of the builders reported that they "usually" included fluorescent lighting in their homes. Half of the electronic contractors said they do so usually (75-100% of the time), and half said they did so frequently (25-75% of the time). This is impressive given that they are probably not subject to Title 24 requirements to use fluorescents for the half of these projects that are remodels,. None of the respondents replied that they "never", "rarely" or "only occasionally" use fluorescent fixtures.

The respondents claimed that they are generally not responsible for the choice to install fluorescent fixtures. All but one of the electrical contractors reported that they only install what they are told to install. Only one electrical contractor claimed to make his own decisions on style, price or efficiency. The home builders reported exercising a little more discretion, with half claiming that they made their own selections, and half reporting they just did what the customer requested.

When asked for the reason that they install fluorescent fixtures in their projects, customer choice was listed as the dominant reason. Code compliance was never mentioned as the primary reason.

- 80% reported using fluorescent fixtures because customer selected it or it was part of specifications of home
- only 20% mentioned code compliance in any form, and always in combination with the other two issues above

3.2 Locations of Fluorescent Fixtures

Fluorescent fixtures in residences were most commonly reported to be installed in garages, followed by kitchen utility applications, bathroom utility, outdoor wall-mounted, then outdoor ceiling-mounted fixtures. The following chart in Figure 3-1 reports the combined percentage of interview respondents who "frequently" or "usually" install the indicated type of lighting:

Indoor Lighting	**Frequently or Usually Install**
Garages	90%
Kitchen utility lighting	77%
Kitchen decorative lighting	4%
Bathroom utility lighting	80%
Bathroom decorative lighting	4%
Other utility lighting	0%
Other decorative lighting	0%
Outdoor Lighting	
Wall mounted	50%
Ceiling mounted	30%
Pole or ground mounted	15%

Figure 3-1- Locations for Fluorescent Fixtures

Another 70% of contractors claimed they "occasionally" or "rarely" installed fluorescent fixtures for kitchen or bathroom decorative lighting. This is actually a remarkably high number, especially since the same group was very clear that they never installed fluorescent lighting for any other decorative or utilitarian purpose. Also, since 95% claimed that they only installed what was directly requested by the homeowner or building specifications, this value implies that someone other than the contractor is selecting fluorescent lighting for these decorative purposes.

3.3 Availability and Satisfaction with Fluorescents

The contractors reported few if any problems with product warrantees, delivery, selection or supply. A few noted problems with sizes and compatibility. However, over 1/3 of the contractors did note that they have received customer complaints or call-backs on the performance of fluorescent fixtures products.

When asked "Have you felt constrained by the selection of fluorescent products available to you?" a few contractors replied that they had experienced problems with compatibility of lamps, sizes, and style selection.

"Sometimes we have problems with bulb limitations or compatibility among different fixtures"

"It can be a very difficult fit for some installations, particularly in bathrooms"

"For tight area applications, spacing has been a problem"

"Fixtures are not always very decorative"

When asked "Have you received any customer complaints or callbacks about the performance of these products?" one third said yes. This was by far the greatest hot button issue in the interview, and prompted the most consistent replies:

Three contractors said their customers complained of lamp performance, poor coloration of light, and humming of ballasts.

"90% of my customers complain about the color given off by fluorescent lights"

Four contractors mentioned that the fixtures don't give off enough light, especially in bathrooms. [this is a common complaint with retailers also.]

3.4 Installation of Lighting Controls

Lighting controls were much less commonly installed then fluorescent fixtures. Of the controls that are installed, the contractors claim that ¾ of them are outside, and virtually all of them are integral with the fixture.

The only reason cited for installing controls was that the customer had requested them. Over half of the builders stated that they never installed controls, because that was the customers' choice after the house was built. Only 8% of the contractors claimed that they "almost always" install automatic controls, while 42% said that they did so "usually," and 27% "occasionally."

Separate photocell and motion detectors were equally popular, followed by timing devices. None of the contractors said that they installed combination devices.

Five contractors complained about the need for re-adjustment with controls, or that homeowners have problems with understanding how to programming the devices.

"Sensors need a lot of adjustment" was a typical comment.

Other than a need for adjustment, which could cause a call-back, none of the contractors mentioned any other problems with controls.

3.5 Conclusions for Residential Contractors

All the contractors interviewed had ample experience installing fluorescent fixtures, and they had few complaints about them. They perceived the installation of fluorescent fixtures as a customer choice issue, rather than a code driven issue.

The greatest problem that they saw with fluorescent fixtures were insufficient light output, or annoying features of the lamp and ballasts. Ballast hum and unacceptable color of light from the lamps were most frequently mentioned. One third of the contractors said that they used decorative fluorescent fixtures occasionally in kitchen or bathrooms, indicating that fluorescent light is no longer strictly limited to utilitarian applications.

The contractors had not experienced much demand for controls, and have much less experience installing them. They uniformly perceive controls as a retrofit option for homeowners, rather than a standard feature of new homes. 75% of controls go on outdoor fixtures, and all controls are reported to be installed integral with the fixture.

Most significant are the issues that were not mentioned in the interviews. The contractors did not complain about a poor selection of fluorescent fixtures, or unreliable performance. They did not complain about the difficulty of installation, or delivery problems. They did not complain about code requirements .

4. RESIDENTIAL RETAILERS' MARKET PERSPECTIVE

A wide range of residential lighting retailers were interviewed. The interviewer asked to speak to the person responsible for selecting and ordering the fixture inventory at each store, or for a group of stores in California. The sample of 23 retailers was split half and half between northern and southern California, with almost ¼ of the respondents outside of the major metropolitan areas. Four were national chains. ½ were chain stores, ½ single location stores. Almost half could be classified as hardware stores, about 1/3 were lighting specialty stores, and the remainder were department stores or multi-product home retailers. Almost all the retailers sold to both residential contractors and consumers. Two sold only to consumers and one sold only to contractors. One store specialized in fluorescent lighting only.

At the beginning of the interview, before more specific issues were discussed, the retailers were asked to describe their best selling energy efficient lighting products, in order to assess their knowledge of the issue, and discern which "efficient" products they were most likely to promote.

There was considerable range, and some confusion, in what these retailers judged to be "an energy efficient lighting product." When asked to name their three best selling energy efficient products, almost 1/3 of the retailers mentioned some form of standard incandescent lamp such as "Softwhite bulbs". Halogen lamps and ceiling fans were also frequently mentioned. 2/3 of the retailers listed at least one fluorescent product, which included "cool white tubes," compact fluorescent fixtures, and 25 Watt shop lights. Generally fluorescent products were described very generically, such as "4 foot tubes", while other products were described with a manufacturer and product name, such as "Sylvania point fan/light combo fixtures." Compact fluorescent products were mentioned with the same frequency as full size fluorescent products. Controls were mentioned by 17% of the retailers as a best seller.

4.1 Types of Fluorescent Fixture Products

The retailers averaged 30% of both their indoor fixtures and outdoor fixtures sold for fluorescent lighting. The most common answer was about 8-10% of the fixtures sold, but some stores sold a preponderance of fluorescent fixtures, raising the average. A few lighting specialty store owners were openly hostile to the idea of fluorescent lighting, and to government mandates for efficient lighting.

In terms of the variety of products carried, garage fluorescent lighting had the greatest popularity in terms of the number of retailers who carried the product

and the variety of products carried, followed closely by kitchen utility lighting, then bath utility lighting. Outdoor wall mounted, then ceiling and ground mounted where the next most common fixtures carried.

The retailers reported the percentage of dedicated fluorescent fixtures that they carried for the applications listed below in Figure 4-1. The products were also ranked for their "popularity," a combined function of the number of stores carrying the product and the number of different products carried. The most common fluorescent fixture type, with the greatest variety of options was for garages. The second most popular was for kitchen utility lighting, the third, bathroom utility lighting, and the fourth, outdoor wall-mounted lighting.

Indoor Lighting	Percent of retailers who carry fluorescent fixtures for:	Popularity Rank
Garages	96%	1
Kitchen utility lighting	100%	2
Kitchen decorative lighting	26%	8
Bathroom utility lighting	96%	3
Bathroom decorative lighting	22%	9
Floor and/or table lamps	17%	7
Other utility lighting	30%	10
Other decorative lighting	0%	11
Outdoor Lighting		
Wall mounted	74%	4
Ceiling mounted	65%	5
Pole or ground mounted	65%	6

Figure 4-1 - Fluorescent Products Carried

Decorative fluorescent fixtures were carried by only a minority of the stores. Of the 25% of stores that carried any decorative fluorescent lighting 2/3 of them were small lighting specialty stores. One large national chain said they carried decorative as well as utility fluorescent lighting. An additional 15% of stores said they could special order decorative bathroom or kitchen fluorescent fixtures. Thus, the consumer would have to work very hard to find any choice of non-utility fluorescent fixtures.

The stores averaged a selection of 4 to 5 of each indoor fluorescent product type that they carried and 3 to 4 of each outdoor fluorescent fixture type.

4.2 Attitudes Towards Fluorescent Fixtures

Eighty three percent of the retailers expressed confidence that the market for fluorescent fixtures would grow in the near future. Greater energy efficiency was

mentioned by over half of the interviewee for a reason why fluorescent lighting was likely to become more common in the future. Three retailers were adamant against any kind of government regulation on the efficiency of lighting.

Fifty seven percent of the retailers reported that they had received customer complaints on fluorescent fixtures. Humming ballasts, and poor light color were mentioned by 25% of the retailers as a barrier to fluorescent fixtures become more common. Low light output was mentioned by another 17% as a major barrier to greater popularity of the fixtures:

> "Not enough light is produced by these fixtures"

Early lamp failure, "sloppy fixtures" and difficult assembly were also mentioned by a few retailers. Lack of good choices in fixtures was mentioned by a few of the retailers:

> "Maybe someone could develop a better decorative fixture. Most fixtures available are not very attractive"

4.3 Types of Lighting Control Products

Controls are a less common and less popular item than fluorescent lighting, as shown in Figure 4-2. Whereas all retailers carried at least basic utility fluorescent lighting, and averaged 4 or 5 versions of each product type, only 75% of retailers carried any photo controls, 65% carried integral motion detectors, and 48% carried integral timers, and they averaged less options (3 or 4) of each product type.

The "popularity Rank" is a combination of the number of retailers carrying the product times the variety of a given product carried. Photo controls were most common, followed by motion detectors. Combination controls were almost non-existent as a product line. Almost three times as many controls were sold as part of a fixture as were sold separately.

Control is part of fixture	Percent Carrying Control Products	Popularity Rank
Timing device	48%	3
Motion detectors	65%	2
Photocells	74%	1
Combined motion detector with photocell	4%	7
Control is sold separately		
Timing device	22%	6
Motion detectors	39%	4
Photocells	35%	5
Combined motion detector with photocell	0%	8

Figure 4-2 - Control Products Carried

Fifty seven percent of retailers believed that the market for controls would grow in the near future. Asked for reasons that controls might become more common in the future, 40% of retailers volunteered that that security was becoming more important to consumers, driving the market for controls. Security outnumbered comments about increased energy efficiency by 2 to 1.

"Security conscious consumers make these devices popular."

Seventeen percent of retailers said that they had received customer complaints about controls. Comments and complaints about performance of controls were quite varied, and included:

"Automatic control devices are sometimes triggered or activated when they should not be"

"Most people do not know how to adjust these control units"

"Motion detectors don't have long lifetimes, need more longevity"

"Poor manufacturing quality; made in China"

"People really like them [lighting controls]"

"Design more controls to handle fluorescent"

4.4 Conclusions on Retail Market Barriers

Retailers showed very little sophistication when it came to understanding fluorescent lighting or controls. Although the people interviewed were responsible for ordering the stores inventory of fixtures and controls, they showed little interest or detailed knowledge about the technology or manufacturer's product lines for these product types.

Similarly, their understanding of lighting energy efficiency in general seems to be rudimentary, no more than might be expected of the average homeowner. One third of the retailers included standard incandescent lamps, many by specific product name, in their list of their best selling energy efficient products. Retailers that mentioned fluorescent lighting as a best selling efficient product were likely to describe it generically, such as "4 foot fluorescent tubes" or "cool white tubes," rather than in specific detail.

Fluorescent utility fixtures for garages, kitchen and bathrooms are considered to be a staple item, carried by all lighting retailers. Outdoor fluorescent lighting is carried by only ¾ of the retailers, as are integral photo controls or motion sensors. Decorative fluorescent lighting, and controls sold separately from a fixture are relatively rare, carried by ¼ and 1/3 of the retailers respectively, with fewer product lines available.

While over 80% of the retailers believed that the market for fluorescent lighting would grow significantly in the next five years, over half of them also had serious objections to the quality of products currently available to them. They perceived fluorescent fixtures to have low light output, and other objectionable characteristics, such as poor light color and ballast hum. There was no mention that these problems could be solved with alternative technologies, or that the situation was improving. There seemed to be no awareness of the major changes in technology that have occurred recently with fluorescent lighting that could address these problems. Indeed, most of the products that they are selling seem to be older fluorescent technologies, "cool white tubes" and "circline fixtures."

The retailers evidenced some greater awareness of changing technology with controls. A few spoke of "miniaturization" or volunteered how much consumers really like controls.

The retailers lack of understanding of fluorescent technology would seem to be a major market barrier for residential consumers. A handful also voiced considerable hostility to government intervention, something that did not occur at all with any of the residential contractors interviewed, or commercial lighting professionals. Although increasing popularity of energy efficiency or "energy conscious consumers" was mentioned by over half of the respondents, the retailers in general did not demonstrate much depth of knowledge on the issue.

5. COMMERCIAL LIGHTING PROFESSIONALS' PERSPECTIVE

A total of 48 professionals involved in lighting design and installation around the state were interviewed about their attitudes and practices related to lighting energy efficiency. For each firm, the interviewer asked to speak to the person most knowledgeable about the firm's commercial lighting design practices. In most cases this was the owner of the company.

The research objectives were to determine their attitude toward

1. current lighting efficiency practices;
2. current lighting code requirements;
3. education resources for lighting efficiency;
4. organizations and certification programs involved with lighting.

The composition of the interviewed group was as follows:

Electrical contractors	42%
Design/build electrical contractors	8%
Electrical engineering firms	21%
Lighting design firms	17%
Lighting maintenance firms	13%

Half were from Northern California (from the San Francisco, San Jose, Sacramento phone books) and half from Southern California (Los Angeles, San Diego, Orange County phone books). Overall, 15% were located outside of the major metropolitan areas (Redding, Salinas, San Luis Obispo phone books).

Their project types covered a full range of commercial building types. The members of the group averaged 160 projects per year, averaging about 21,000 SF each. Lighting maintenance firms worked on the largest buildings (average 39,000 SF), and lighting designers averaged the most number of buildings per year (almost 400 per year). Overall, the group's estimate of their average square footage per year represents about 4% of the new construction and renovation square footage in California.

5.1 Feasibility of Improving Lighting Efficiency

The people interviewed universally agreed that it would be possible to reduce lighting energy use in commercial buildings, and believed that it could be feasibly reduced by 15% on average. The amount of reduction that they thought was

realistically possible varied with the type of firm, with lighting designers estimating savings 5% higher than electrical engineers, who were the most conservative of the group.

Average estimates of feasible commercial lighting energy use reductions, beyond current Title 24 standards, by type of firm:

Lighting design firm	18%
Lighting maintenance firm	15%+
Electrical contractor	15%-
Design/build electrical contractor	14%
Electrical engineers	13%

5.2 Use of Professional Engineers and Lighting Designers

The firms were asked how many registered engineers and specialized lighting designers they had on staff.

As would be expected, electrical engineers had the most number of professional engineers on staff, averaging almost two per company, followed by design/build contractors with ¾ of the firms having a staff engineer, then by lighting design firms with one half employing a registered engineer. Lighting maintenance firms came next, and electrical contractors last, with only 10% of firms employing a professional engineer.

Average number of professional engineers (registered PE) reported on staff:

Electrical contractors	0.1
Design / build electrical contractors	0.8
Electrical engineering firms	1.7
Lighting design firms	0.5
Lighting maintenance firms	0.2

All of the lighting design firms had at least one person on staff who specialized in lighting design. Half of the electrical engineering firms claimed to have at least one staff member who specialized in lighting design. Less than 1 in 4 of the other types of firms said that they had a staff member who specialized in lighting design.

Less than 1/5 of the respondents said that their staff had any special certifications in lighting, and only one half said that a staff member had had any specialized training in lighting. This suggests that there is relatively little motivation for these businesses to pursue special lighting training or certificates,

even though lighting is a major part of their business. Electrical contractors were the most likely to have pursued special lighting courses and certificates, and electrical engineers were the least likely.

5.3 Efficiency of Current Practice

All of the interviewees reported that their projects were usually subject to Title 24 lighting restrictions. Only two electrical contractors reported that their projects were likely to exceed Title 24 requirements because of "special conditions or exceptions."

It is important to note that all of the professionals interviewed were aware of Title 24 lighting requirements, and none claimed that "Title 24 doesn't usually apply to our projects." This should be interpreted as 100% awareness of the code among this group of professionals in California. (In comparison, a recent study in Iowa found that less than half of local building officials were even aware of the existence of the Iowa commercial energy code[1])

The surveyed group reported that, in general, the energy use of their projects was:

At required levels	21%
Slightly more efficient (5% to 10%)	58%
15-20% more efficient	13%
More than 25% more efficient	4%
Special requirements or exceptions often necessitate greater energy use than basic standards	4%
Title 24 doesn't usually apply to our projects	0%
Other	0%

These numbers are entirely consistent with the findings of the commercial baseline survey, which found that the commercial building stock of 5 years ago, in 1992-1994, was about 5% more efficient than the Title 24 baseline.

Electrical engineers were the most conservative in assessing the energy efficiency of their own projects, with 20% saying they were right at Title 24 required levels, and the remaining 80% saying that they were usually 5-10% better than Title 24. In contrast, all other groups had 15% or more respondents who reported that they usually exceeded Title 24 by more than 15%. Of the

[1] Iowa Department of Natural Resources. Survey by the Iowa Association of Municipal Utilities (IAMU) of 375 Iowa towns on energy code awareness and enforcement, 1996.

lighting designers, 38% thought that their projects usually exceeded Title 24 by more than 15%.

Of the respondents, 85% thought that reducing lighting energy consumption by 10% would be "easy," compared to 2% who thought it would be "impossible." While there was less enthusiasm for reducing lighting energy use by 25%, with 73% responding that it would be "difficult or very difficult," only 6% of the respondents replied that it would be "impossible" to do so.

5.4 Acceptable Energy Efficiency Strategies

The professionals were asked which of the following energy efficiency strategies would be most acceptable to their clients. Most groups, with the exception of lighting designers, followed the same basic ranking pattern. The ranking shows a strong preference for more efficient technologies, and an absolute aversion to doing anything that would reduce lumen levels.

Rankings of energy efficiency strategies (most acceptable to least acceptable) according to **all respondents, except lighting designers**:

1. Select more efficient lamps and/or ballasts
2. Select more efficient fixtures
3. Increase efficiency of design layout
4. Use daylighting
5. Use occupancy sensing controls
6. Select more reflective interior surfaces
7. Improve maintenance practices
8. Use dimming controls
9. Reduce lumen levels

Lighting Designers had a very different pattern of preferred strategies than the other groups. Most striking was the finding that increasing the efficiency of the design layout was their number one choice. Improving maintenance practices and selecting more reflective interior surfaces also ranked considerably higher than the norm. Also, notably, lighting designers gave a lower ranking to any form of lighting controls, such as daylighting, occupancy sensors or dimming controls. Perhaps this is consistent with a preference for design solutions over electronic devices.

Rankings of energy efficiency strategies (most acceptable to least acceptable) according to **lighting designers**:

1. Increase efficiency of design layout
2. Select more efficient fixtures
3. Select more efficient lamps and/or ballasts
4. Improve maintenance practices
5. Select more reflective interior surfaces
6. Use daylighting
7. Use dimming controls
8. Use occupancy sensing controls
9. Reduce lumen levels

5.5 Approach to "Ultra-Efficient" Design

The professionals were asked about the most likely approach that they would take to get ready for a important client who wanted a "state-of-the-art, ultra-efficient lighting project." This list is a good snapshot of the professionals' preferred methods for obtaining new information.

Ranking of actions likely to be undertaken to prepare for an important client who will request an "ultra-efficient" lighting design (average of **all respondents, except electrical engineers**):

1. Send for product literature
2. Ask suppliers/distributor reps for input
3. Ask a utility representative for guidance
4. Attend a conference or trade show
5. Find and read an authoritative book
6. Do the same thing you always do
7. Ask regular consultant to do extra work
8. Have a staff member take a class
9. Hire a specialized consultant
10. Raise your fees
11. Search the Internet for information
12. Hire a new knowledgeable staff member

Spending money to hire additional help is generally at the bottom of the list. It is noteworthy that searching the Internet also ranks very low for this group.

Lighting maintenance firms and electrical contractors put their suppliers or distributors as their top choice as an information source. Indeed, they had identical patterns for all their preferences, suggesting that they think very much alike in this area.

Engineers, on the other hand, had a pattern very different from the norm. They ranked finding information on their own, such as a book or searching the Internet, much higher than the other groups, and ranked asking for help from others, such as suppliers, or consultants, and especially utility representatives, much lower than the other groups. They were also more likely to raise their fees because of additional work.

Ranking of actions to prepare for "ultra-efficient" lighting design (**electrical engineers only**):

1. Attend a conference or trade show
2. Send for product literature
3. Find and read an authoritative book
4. Ask suppliers/distributor reps for input
5. Do the same thing you always do
6. Have staff member take a class
7. Search the Internet for information
8. Raise your fees
9. Ask regular consultant to do extra work
10. Ask a utility representative for guidance
11. Hire a specialized consultant
12. Hire a new knowledgeable staff member

5.6 Continuing Education and Professional Societies

Electrical contractors reported taking the most number of courses in lighting efficiency, most often sponsored by manufacturers, but also sponsored by utilities and the IES. Lighting designers generalized that they had taken "every course available" or "too many courses to list." Engineers listed a few courses, mostly from IES or "college courses."

The Illuminating Engineering Society of North America (IESNA) was the most commonly named organization for the firms to belong to, but still only 25% of the

firms belonged. The next most common organization was NECA (National Electrical Contractors Association), to which over half (10) of the electrical contractors belonged. Another 8% of respondents belonged to the Association of Energy Engineers (AEE). Other than these three organizations, all other organizations were mentioned by only one or occasionally two respondents. Electrical contractors also listed the greatest number and variety of other organizations to which they belonged.

5.7 Conclusions for Commercial Lighting Professionals

All lighting professionals surveyed believed that it was feasible to substantially reduce lighting energy use in commercial buildings in California. Those who identified themselves as lighting designers had the most aggressive view of possible energy savings, while electrical engineers had the most conservative view.

All of the professionals interviewed were knowledgeable about Title 24 lighting standards, and reported that their projects tended to be significantly more efficient than the code requirements. Creating lighting plans that would be 10% more efficient that Title 24 was judged to be "easy", and creating plans 25% more efficient was judged to be "difficult" but feasible.

Electrical engineering firms had the highest number of professional engineers at their firm, and reported that they had lighting education from college. However, they had the lowest participation in professional societies and participation in continuing education on lighting. Lighting designers and electrical contractors were most likely to pursue continuing education on lighting.

Product literature is the single most important source of information on lighting efficiency for the lighting professionals. Accessing the Internet was rated almost the lowest, only slightly more likely than hiring a "knowledgeable new staff member."

6. CERTIFICATION OF LIGHTING PROFESSIONALS

There is a growing movement to develop a system for certifying lighting professionals. A national group, NCQLP[2], will be offering their first exam at the end of 1997. Certification would be based on objective testing for lighting design and technical knowledge. The goal is to improve the standards of practice in lighting design, and to identify qualified lighting professionals to the public. The Energy Commission has been active in pushing for certification, through recommendations from the ALPAC and development of educational programs which are intended to lead toward certification. Further support for certification is one of the lighting policy options considered in this study.

In studying this topic, thirteen knowledgeable people were interviewed on the subject: ten utility efficiency program representatives from four major California utilities (PG&E, SCE, SDG&E, SMUD), and three prominent lighting designers and electrical engineers. These utility representatives have been responsible for actively promoting efficient lighting strategies to architects, engineers, building owners and contractors to encourage the adoption of efficient lighting systems. Thus, they are intimately familiar with all of the market barriers to adoption of more efficient commercial lighting systems.

6.1 Types of Lighting Professionals

Types of people who might pursue lighting certification include:

- lighting designers
- architects
- electrical engineers
- electrical contractors
- interior designers
- utility representative
- manufacturers representatives
- government administrators
- facility managers
- lighting maintenance contractors.

All of these types of professionals can become involved in lighting design and layout. The two most common are electrical engineers and lighting designers. Electrical contractors are frequently involved in designing lighting layouts by default since they install lighting that may not have been otherwise “designed.”

[2] NCQLP = National Council on Qualifications for the Lighting Professions

There was a clear consensus among this group that lighting designers see the higher end, custom jobs. One utility rep who formerly worked as an electrical engineer said that he was always assigned to the "back of the house" on a given job, and the lighting designers got the important public spaces. So, for example, on a hotel the lighting designers worked on the lobby and public function rooms, while he did all of the hallways, offices, kitchen, and utility areas.

6.2 Efficiency Levels

There was also a consensus that having a space designed by a "qualified" lighting designer did not necessarily increase the energy efficiency of the resulting plan. Energy efficiency is not necessarily a primary goal of all lighting designers; other design objectives may be paramount, such as visual impact or enhancement of the architecture. There was strong agreement that the key to an efficient design was a sophisticated client, not a sophisticated designer.

> "The lighting designer's or electrical engineer's liability stops at meeting code requirements. It's really the client who drives the market beyond code compliance."

In the interviews, the first reaction to the idea of certification was inevitably negative.

> "Lighting certification is overkill: why, we see a whole lot of buildings that don't even have an architect!"

> "Very few people responsible for lighting design try to make a system more efficient. Maybe on 10% of the plans that we see."

In general, the utility reps estimated that only 5-10% of the plans that they see (which tend to be the higher-end, more progressive buildings) included work by someone they would consider a qualified lighting designer. Of the remaining plans, they estimated that 40-60% were designed by electrical engineers and 40-60% were laid out by electrical contractors.

It was generally felt that electrical contractors were just as likely to pursue an efficient design as electrical engineers. Indeed, one rep suggested that electrical contractors are often more motivated to learn about the latest in lighting.

> "They pursue lighting information because they are truly interested. If they consider themselves a lighting designer, its because they really care about lighting."

This observation was entirely consistent with the electrical contractors self-reported interest in lighting education and certification, from the commercial practitioners interviews (Section 5.5 above).

6.3 Attitudes to Certification

After consideration, most of the utility reps agreed that certification would help to increase the credibility of people knowledgeable about lighting, and would set a standard of practice which would motivate more engineers and contractors to learn more about lighting. One rep complained about:

> "…engineers who are sure they know it all. If they didn't learn it 30 years ago, they figure its not important."

(This observation is also consistent with the engineers self-reported lack of interest in continuing lighting education.)

It was observed that engineers, architects, and design-build contractors may resist a move to certification if they perceive that in infringes on their prerogatives.

> "Electrical engineers should be reassured that no job would be done without an electrical engineer."

It was suggested that it could potentially be confusing to clients that a "certified lighting designer" still could not be responsible for wiring plans and panel design, for which an electrical engineer is required.

Most agreed that "there is confusion in the market" about who is qualified to design lighting systems.

> "Most lighting designers are selected based on their reputation and portfolio, which carries a lot of weight. But the assumption is that electrical engineers will do it all. A certification program would distinguish between engineers and contractors with and without lighting experience. Lighting designers would not be impacted."

Proponents of certification see it as a primary driver for more education in lighting. One engineer who is well know in the lighting community professed:

> "I received no education in school on lighting. The engineering bias is all towards calculations, not performance or quality."

6.4 Conclusions on Certification

There is not a clear consensus that certification for lighting designers would increase the overall energy efficiency of lighting plans produced in the state. It was, however, generally believed that the quality of lighting projects would most likely improve, as building owners would be better able to distinguish consultants who were knowledgeable about lighting. There was clear consensus that a certification program would work to raise professional standards in the lighting field and would set a standard that would become an important motivator for

additional education for practitioners, especially those who are at the margins of the lighting design field.

All interviewed agreed that building clients are the primary determinants of when building lighting efficiency will exceed minimum code standards. Perhaps they are more important targets for information on good lighting design and how to demand it from their designers.

7. SKYLIGHTING MARKET EVALUATION

A special survey was performed to explore the question of skylighting, by which we mean the use of skylights to provide usable ambient lighting inside buildings (as opposed to monumental skylights over atria or lobbies). When used in conjunction with photocell controlled lighting reduction, skylighting can be a viable energy efficiency measure. Title 24 is set up to provide modest credits for skylighting.

To explore this subject, sixteen interviews were conducted: three with major skylight manufacturers, ten with utility efficiency program representatives who have worked to promote skylighting, and three with architects involved with premier skylighting projects. The interviews asked:

- Where have your best successes been in implementing skylighting?
- What are the barriers to greater utilization?
- What could be done to support increased use of skylighting in commercial buildings?

7.1 The Market for Skylighting

The group agreed that to date, the biggest penetration of skylighting is in warehouses, big box retailers (Home Depot, Price Club, etc.), grocery stores, and schools. There has been a dramatic recent upsurge of interest in skylighting among retailers, especially big box retailers and grocery stores. Two skylight manufacturers reported that they had to increase their manufacturing capacity to meet this increased demand, and that they were busy retrofitting national retailing chains with skylights as fast as possible.

In general, this dramatic shift was believed to have occurred because retailers have become convinced that the higher levels of light and the better quality of light available from skylights will increase their sales volume, and thus skylighting gives them a competitive advantage. The "Walmart skylight story[3]" was most commonly cited as the initiator of this shift.

Experience with promoting skylights in the past few years has concentrated mostly with skylighting manufacturers themselves, and with utility programs. Southern California Edison has had the most active program promoting

[3] Walmart installed skylights in one half of a store in about 1993, and experienced increased sales volume in that one half, regardless of which products were displayed there. This "story" has been reported in many conferences, newspaper articles and books, but not formally analyzed or published.

skylighting, with several staff consultants who have worked directly with customers on the design and installation of successful skylighting systems. PG&E has a customized peak demand rebate available for skylights: “But there have not been as many takers as we hoped. It usually comes out as a 3 to 4 year payback, which isn’t enough for most owners.” SDG&E has not really promoted skylighting: “We maybe consider it in one out of one hundred projects. The design teams really don’t have a clue.”

One utility rep who has been involved in numerous skylighting projects stated that “the most common mistake is under-sizing the skylights. Designers have no concept how to optimize the area, and so are very timid. The results are unimpressive. When they do it right, everyone is delighted. They can get all the light they need without extra heat.”

7.2 Barriers to Skylighting

Several barriers to increased utilization of skylighting were identified. They are listed in approximate order discussed by the interviewees.

7.2.1 Perception of Leaks

Everyone interviewed listed fear of leaks as the single biggest barrier to increased utilization of skylights. Everyone interviewed also agreed that they knew of no current skylights that actually did leak. Condensation which is not handled properly is often misinterpreted as leakage. It was reported by a number of sources that architects who had experimented with glass skylights the 1950s had bad experiences with roof leaks then, and had sworn that they would never do them again. They experienced huge liability problems from roof leaks: 40 years later that bad experience is still having a strong effect…. It was clear that people have very long memories for bad experiences.

7.2.2 “Normal” Lighting

Another barrier discussed was that skylighting was perceived to be abnormal, “and developers want a normal building.” One representative recounted a situation where a developer was only persuaded to include skylighting when he was assured that the skylights could be removed when it was time to sell the building, so it could be returned to “normal.”

As opposed to European building codes, American codes have no requirements for minimum daylighting in commercial buildings. This lack of a code requirement has allowed American commercial buildings to rely almost entirely on electric light for work, maintenance, security and emergency lighting. [Some interviewees asked, why aren’t emergency exit ways required to have minimum daylighting so

they're not pitch black during disasters? Why aren't "essential" buildings, like hospitals, police stations and schools required to have minimum daylight levels? Currently, there aren't any safety requirements for hospitals or other critical facilities to provide daylighting, which instead rely on generators and battery packs to provide emergency lighting, which of course are most likely to fail in fires, and earthquakes.]

Many people assume that skylighting is a second class form of lighting buildings, maybe from association with old warehouses. Some feel it produces low levels of light (inadequate design); it is unreliable (cloudy days); there are color shifts at different times of day; there is no sparkle; there is poorer distribution of light than electric lighting. All of these issues can be addressed via proper design.

7.2.3 Integrated Design

Another significant barrier is that skylighting requires integrated design, with coordinated work among a number of the design professions. Architects and engineers have to employ different techniques than their "standard practice," and they often don't know what alternative solutions can work. The biggest impact on the design of a building, according to one manufacturer, is the need to design without a drop ceiling. "This forces mechanical engineers and electrical engineers to re-think their standard approaches. Mechanical engineers see extra volume of air that has to be conditioned. But they can go to a stratified system, which can be very energy efficient. We've seen a number of good projects using stratification."

Architects don't often think of envelope solutions to increased energy efficiency. Architects often must make the decision to include skylighting before an electrical engineer or lighting designer is brought onto a job. Electrical engineers don't like controls, feeling that they are too fussy, requiring too much design supervision time.

Some chain building owners have perfected a basic design that can be repeated. More typically, however, lack of knowledge from the design team can result in a poor design, which then won't get repeated. Professionals don't really have design tools at their fingertips to help them utilize skylights with authority. DOE-2 is the primary analysis tool, but it is so complicated that it can only be used on the most high end jobs. Other than DOE-2, skylight manufacturers provide most of the analysis. Architects are reportedly often reluctant to ask for this help, to take advice from the manufacturer.

7.2.4 Security and Safety

Building owners often have concerns about security and safety. They remember stories about a burglar falling though a skylight and suing the owner. Vandal proof materials have largely solved this issue, but one memorable story can persist such a concern.

7.2.5 Controls Adjustment

Adjustment and maintenance of photo sensors and dimming controls are the most consistent problem encountered with skylighting applications. The control systems typically required additional design effort and additional labor to install correctly. One skylight manufacturer talked about climbing a ladder to calibrate the dimming system of each skylight while having the store manager eye-ball the light levels from below. Controls are also reported to be overridden in the field, especially by second generation building managers who don't understand the original intent of the building.

7.2.6 Lighting Quality

People who promote skylighting think that the primary attraction is improvement in the quality of light to the occupants of the building. Any energy savings are considered to be a secondary motivation. However, it is very difficult to explain quality of light to a potential customer. Everyone surveyed said the only way to truly convince people to use skylighting is to take them to another building that has skylights, so that they can experience the improvement in the quality of light directly. Unfortunately this is a very inefficient marketing approach.

All of those interviewed believed that more authoritative studies documenting the improvement in lighting quality would be enormously useful in overcoming this barrier. Even better, documenting the impacts of this improvement in lighting quality in terms of productivity, retail sales, employee satisfaction, or other metrics, could have a seminal upon building owners acceptance of skylighting. This impact was dramatically evidenced in the sudden shift of big box retailers to skylighting after the "Walmart skylight story" surfaced (see above).

7.3 Conclusions on Skylighting Market Barriers

Skylighting is an underutilized lighting resource that is significantly hampered by a number of market barriers which could be effectively remedied. Most of these barriers are based on negative attitudes and poor flow of information to the necessary actors, which can both be addressed with educational outreach.

From the commercial survey, it is clear that lighting designers do not believe that daylighting is a very feasible lighting efficiency option. Electrical engineers didn't rank it very high either. These practitioners do not receive any formal instruction about skylighting design and analysis tools. They all tend to consider it someone else's discipline.

One architect who has successfully completed numerous projects with skylights said that he doesn't have any problems with his engineering consultants, because "I do all the basic design myself. I only hire consultants who will do what I want." When daylighting was required by the CA Department of Education in the 50s and 60s for all K-12 schools, architects learned how to design with it. Since then, it has become a lost art.

Inclusion of skylighting in design and professional curriculums would be an important step in overcoming this information barrier. Some design tools exist, but could be made more accessible for architects and other designers. But designers will inevitably seek out tools and education if there is a strong client demand for a technique. While this client demand is clearly starting in the retail sector, client demand in other sectors requires additional marketing tools.

The solution to the most technical market barrier, the current complexity of control systems, is most likely to be driven by the manufacturers of skylights and controls. A larger perceived market is likely to push innovation in this area.

Increasing the market for skylighting is most likely to be driven by studies which document cases of enhanced retail sales, industrial productivity, educational performance, employee satisfaction, worker health, and/or safety during disasters issues due to skylighting. Many anecdotal stories exist, which lack authority, but which suggest obvious paths for more careful studies.

Unfortunately, there are no major advocacy groups for daylighting to sponsor these studies. Given the multiple players involved in a skylighting system, and the small market segment of each, it is unlikely that any one will take the lead in sponsoring authoritative studies. The CEC could provide centralized leadership to focus the various components of the industry to sponsor such studies, which would benefit not only the industry but also provide a long term benefit to the people of the state with better lighting quality and greater energy efficiency in their buildings.

8. APPENDICES

8.1 Manufacturers Interview Form

8.2 Residential Contractors

8.2.1 Interview Form

8.2.2 Summary Sheets

8.3 Residential Retailers

8.3.1 Interview Form

8.3.2 Summary Sheets

8.4 Commercial Lighting Professionals

8.4.1 Interview Form

8.4.2 Summary Sheets

8.5 Certification of Lighting Professionals Interview Form

8.6 Skylighting Market Interview Form

8.1 Manufacturers Interview Form

Manufacturers Interview

[Introduce yourself.]

Hello. We are conducting interviews with manufacturers of lighting fixtures on behalf of the California Energy Commission. The Commission has been involved in a multi-year study of the potential for future lighting energy efficiency. We would like you to help us get perspective on your portion the on the lighting fixtures (and/or controls) market, and you see are limitations to greater energy efficiency.

[First confirm identity of target interviewee, position and direct phone number in case there is a need to call back.]

This conversation will take about 15 minutes of your time.

> *[assurances of confidentiality, if needed: We would like to be able to list your name, position and company in the acknowledgments as having participated in an interview and assisted us with our research. However, we will not make any direct attributions to you in our reports, or report on any company specific information. Any quotes or other information will be attributed to generic descriptions, such as: "a controls manufacturer says…".]*

1. Which of the following products does your company manufacture?

   [Have them describe product's special characteristics or special markets, if you are unsure or unfamiliar….]

   - Residential outdoor lighting fixtures, esp. porch and "lantern" fixtures
   - Residential outdoor lighting controls (esp. photocell-motion detector combos)
   - Residential indoor ceiling fixtures, high and low end
   - Commercial incandescent and CFL ceiling fixtures
   - Commercial occupancy sensors

2. Review check list, keeping as quick as possible. [If person seems impatient, save distribution questions and other checklist items for end.]
3. How important is the California market for this product? Roughly, what percentage of this product would you estimate that your company sells in CA?
4. What is distinctive about the CA market for your product? Are you effected by Title 24? Are you effected by other regulations? Utility programs? Any other programs? Other trends in CA?
5. Do you notice any greater demand for your energy efficiency products in CA than other states? If yes, why do you think so? What other states do you see marked demand for your energy efficient products? Why do you think so?

6. What change in the market has had the biggest impact in your production of this product?

7. Do you think there is potential for this product to be adopted by a vastly larger market? Why, or why not?

[To help them think through potential limitations, review an appropriate list of potential market limitations, remembering to keep the conversation short: These need to be asked in conversational form. Ask follow up questions for key issues…like, what would it take to overcome this limitation? Who should/could undertake it?]

- Manufacturing barriers
  - cost of changing manufacturing equipment, limitations on supply of materials
  - technical difficulties in producing product
  - warrantee problems, reliability worries
- Distribution barriers
  - product too fragile, too big, too small, for easy transportation or storage,
  - market area too diffuse,
  - no knowledgeable or reliable distributors
- Marketing barriers
  - product introduction costs, difficulty in differentiating from competing products, difficulty in communicating value of product,
  - difficult to target market, market too specialized,
  - fluctuating market (construction boom and bust…)
- Institutional barriers
  - conflicts with codes, such as fire, energy, structural/seismic or NEC
  - difficulties with UL rating or insurance requirements
  - need for other special ratings or approvals
- Equipment barriers
  - lack of compatibility with other equipment in buildings (RF interference, surges…)
  - lack of coordination with other manufacturers (need for standards…)
  - lack of support from associated products (no fixtures designed for CFL lamps…)
- Practice and/or installation barriers
  - lack of knowledgeable architects, engineers, contractors
  - cross-discipline confusion, too much coordination by variety of disciplines
  - requires specialized labor to install
  - need for excessive calibration, adjustments
- Consumer barriers
  - unacceptable performance (hum, bad CRI, no dimming, slow startup…)

- poor aesthetics (no sparkle, poor light distribution, excessive brightness, wandering color…)
- facility management issues (too many parts, difficulty ordering replacements, difficult to maintain…)

7. How do you think your product would be impacted if:
   [these are hypothetical only!]
   - If the OEM price of components came down dramatically? (How much is dramatic?)
   - If the quality of OEM components went up dramatically? (What needs to improve?)
   - Title 24 were to require its inclusion in all new construction?
     Immediately, vs. 10 years from now?
     If instead of a state energy code, it was a national energy code?
   - If EPA launched an “Energy Star” campaign for this product/
   - If equivalent efficient products were mandated by a state or national appliance standard.
   - If the industry launched a joint advertising campaign
   - What other strategies do you think might have a positive impact?
8. Thank you so much for your time and thoughts! If you have any other thoughts later you can call me back at…..
9. If you are interested in the CEC’s project, you are invited to attend the public workshop on the final report and recommendations to be held at the CEC in Sacramento. If you would like to attend, or get further information, please call John Sugar at the CEC (916) 654-4563.

8.2 Residential Contractors

Interview Form

Summary Sheets

8.3 Residential Retailers

Interview Form

Summary Sheets

8.4 Commercial Lighting Professionals

Interview Form

Summary Sheets

8.5 Certification of Lighting Professionals Interview Form

Target to interview about two to three utility representatives each from SMUD, PG&E, SCE, and SDG&E who have been responsible for promoting similar programs, and three to four lighting designers.

These conversations were informal and collegial, but were structured around the following questions:

- What percentage (SF) of commercial space do you think is currently designed by a professional “lighting designer” instead of an electrical engineer or electrical contractor who has no special lighting training?
- How would you typify that which spaces are, and that which are not designed by a lighting designer?
- What do you perceive to be the prime market barriers preventing lighting design professionals from enhancing the overall efficacy of their designs?
- How could these best be overcome?
- Do you think any energy savings result from having a professional lighting designer responsible for designing a lighting system? If so, how much, and why?
- Do you perceive that there is a market for certified lighting professionals? If so, how would you describe it? Who would be most impacted, and how?
- What would be barriers to the implementation of a certification program?
- Do you believe that there could be any appropriate requirements for a certified professional? If so, by whom, where or when?
- Do you perceive that certification would impact the overall energy performance of lighting systems installed in the state? If so, how, or why not?

8.6 Skylighting Market Interview Form

Target to interview about two to three utility representatives each from SMUD, PG&E, SCE, and SDG&E who have been responsible for promoting similar programs, three to four skylight manufacturers, and two to four architects responsible for recent skylit buildings.

These conversations were informal and collegial, but were structured around the following questions:

- Where have you had the greatest success promoting sky lighting with dimming controls? What building type or owner types are the most receptive? Why?
- What are the main reasons that are given for not including skylighting in a project? By owners? By architects? By mechanical engineers? By electrical engineers? By building contractors?
- Which of these problems have been real, and which are simply perceived to be problems?
- What do you believe are the prime market barriers for greater installation of sky lighting/dimming systems in the state?
- What are the best ways to overcome these barriers?
- What policies or market conditions do you think would be most effective in promoting sky lighting?